Energy Loss Effects on Heavy Quark Production in Heavy-Ion Collisions at $\sqrt{s} = 5.5$ ATeV*

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The energy loss of fast partons is a good probe of dense matter since a fast parton traversing the medium must experience multiple elastic collisions as well as suffer radiative energy loss. Since the exact loss is unknown, a constant loss, $dE/dx = -1$ GeV/fm, was used to study the phenomenology of heavy quark energy loss at the LHC.

Since heavy-flavored mesons carry most of the heavy quark energy after hadronization, the energy lost by heavy quarks traveling through the quark-gluon plasma is directly reflected in the suppression of large p_T heavy-flavored mesons.

Unfortunately, it is difficult to detect charm or bottom mesons directly with current tracking technology because of the large number of produced particles in central AA collisions. However, the invariant mass of the lepton pairs from heavy quark decays is related to the relative momentum of the $Q\overline{Q}$ pair, the dilepton yields in this region could become an indirect measurement of the heavy quark spectrum. Therefore, it should be sensitive to the energy loss suffered by the heavy quarks as they propagate through dense matter.

We examine the effects of heavy quark energy loss at LHC energies, $\sqrt{s} = 5.5$ TeV for Pb+Pb collisions, including hadronization of the heavy quarks, longitudinal expansion and thermal fluctuations of the collision system, which are important for the dilepton spectrum from heavy quark decays. At the LHC energy, the heavy quarks are produced at sufficiently large p_T for the hadronization mechanism to be important. Because of the longitudinal expansion, the momentum loss in the longitudinal direction is quite different from that in the transverse direction. Depending on the actual number of scatterings, the heavy quarks can escape the system without energy loss or lose enough momentum to be stopped entirely. However, heavy quarks cannot be at rest in a thermal environment. In the most extreme scenario when they are stopped, they must have a thermal momentum distribution in their local frame. The resulting suppression of high invariant mass dileptons is then very sensitive to the phase space restrictions imposed by the detector design.

A comparison of the dilepton spectra integrated over all phase space before and after energy loss would naively suggest that the overall effect is small. However, heavy quarks and antiquarks in a pair tend to be separated by a significant rapidity gap. This gap can cause the invariant mass of the subsequent lepton pair to be large. However, once the finite detector geometries are included, the effect of energy loss becomes more dramatic.

We find a strong suppression of high mass dileptons from heavy quark decays due to the energy loss when $|dE/dx| \geq \langle p_T \rangle / R_A$. The dominant contribution to the dilepton continuum for masses greater than 5 GeV is from $b\bar{b}$ decays. Transverse flow, which could lead to a higher effective temperature, T, and thus enhance the low p_T heavy quark yield and, consequently, the low invariant mass dilepton yields, should be investigated.

To determine whether dileptons from heavy quark decays can indeed probe the energy loss, the most important factor is the magnitude of the random hadron decay background. This deserves further study, particularly since high p_T pions will also experience quenching effects and be suppressed in high-energy heavy-ion collisions.

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